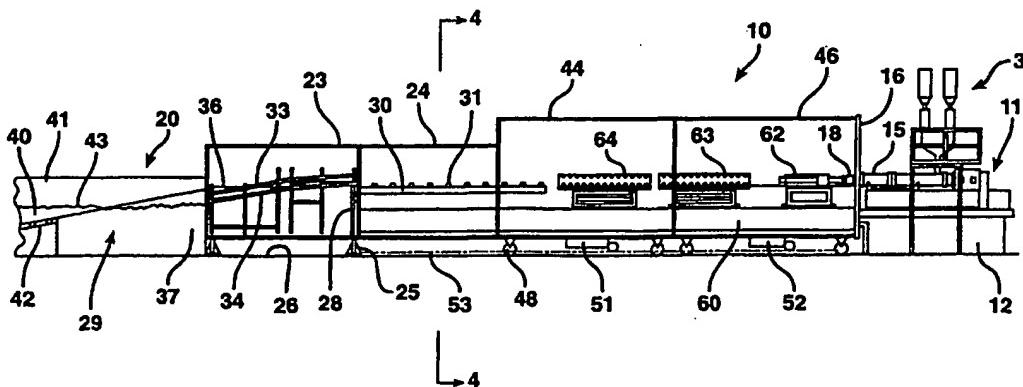




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: VACUUM EXTRUSION SYSTEM AND METHOD



(57) Abstract

A vacuum extrusion line includes a vacuum chamber (10) having an extrusion die (18) at one end and a water baffle immersion cooler (20) at the other end for extracting the extrudate to atmosphere, extrudate shaping and sizing equipment (62, 63, 64) downstream of the die (18), a large diameter fixed bulkhead (16) at the die (18), first (44) and second (46) large diameter movable sections surrounding the shaping and sizing equipment (62, 63, 64), and a smaller fixed section (24) of the chamber (10). The first section (44) sealing against the second section (46) and the fixed section (24) and telescoping over the fixed section to form a gap (68) with the second section (46) being movable within the limits of the gap (68). The second section (46) also seals against the large diameter fixed bulkhead (16). In this manner the downstream equipment (62, 63, 64) can be fully exposed by movement of one or both movable sections (44, 46), and adequate volume and spatial working environment is provided for large through-put.

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VACUUM EXTRUSION SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

Such prior application discloses a horizontal barometric leg of the type shown in *Pagan* U.S. Patent No. 4,783,291. In the *Pagan* patent, a vacuum chamber includes an extrusion die at one end forming an extrudate. After passing through sizing, calibration and draw off equipment, for example, the extrudate exits the vacuum chamber through a water baffle. The extrudate passes over a dam and dips into a pond to exit the chamber through the pond. The pond has two sections or levels, one with a higher level within the chamber during vacuum and one with a lower level outside the chamber. A circulating system keeps the pond level within the chamber from overtopping the dam during vacuum extrusion. The pond provides full immersion cooling during vacuum extrusion as well as providing a continuous water baffle seal for the extrudate exiting the chamber. The extrudate may be cut and processed in atmosphere after it leaves the lower level or section of the pond outside the chamber.

In such prior *Lightle, et al.* application there is disclosed a horizontal barometric leg vacuum extrusion line with a support truss extending from the dam to a fixed bulkhead, the die being mounted on the end of the extruder projecting through the fixed bulkhead. Calibration and sizing or draw-off equipment is mounted on the truss.

The chamber surrounding the truss includes a fixed section and a telescoping section which can move away from the bulkhead telescoping over the fixed section to provide access to the die and the downstream equipment.

If some of the downstream equipment is within the fixed section, the fixed section is entered as one would a cave or tunnel. The system with the single movable section telescoping over the fixed section is quite adequate for medium to low through-puts, but is not necessarily adequate for large through-puts and/or extrudate cross-sections with foaming extrudates. Through-puts are normally expressed as pounds or kilograms per hour. For example, smaller through-puts typically may be two hundred pounds (90.7200 kilograms) per hour or less, while larger through-puts may typically be two thousand pounds (907.2000 kilograms) per hour or more.

When a mishap or mayhap occurs, especially during system start-up, the operators need to open the chamber quickly and obtain access to the errant downstream equipment quickly. The operators not only need access quickly, they need access with an adequate

spatial working environment. Without such, the vacuum chamber may literally fill up or start to fill up with extrudate, especially foam extrudate, requiring the whole system to be shut down.

With higher through-puts, problems need to be addressed more quickly, and the
5 chamber of the system requires larger volume around the downstream equipment, not only to accommodate the equipment, but also operators around the equipment with adequate spatial working environment to obtain access to the equipment and any misdirected extrudate.

10

SUMMARY OF THE INVENTION

The vacuum chamber of the present invention utilizes a fixed large diameter entrance bulkhead plate. A first section with a large diameter is movable and seals against a second larger section, and telescopes over a smaller diameter fixed section which includes the dam and the higher level portion of the pond of the water baffle seal. The
15 second larger section may move within the gap created by movement of the first, and seals against the first and entrance bulkhead plate. A truss supporting the downstream equipment extends from the dam to the fixed bulkhead through the movable large diameter sections. In this manner all of the downstream equipment may be mounted within the two movable large diameter sections providing adequate volume for large
20 through-puts as well as a good spatial working environment.

Both large diameter sections may quickly be opened with the first telescoping over the smaller fixed section, and the second section may be moved with the first section or within the gap provided by the first section. In this manner any portion of the downstream equipment may quickly be completely exposed.

25 The first section may be locked to the fixed section, and fluid seals may be employed between the bulkhead and second section, the first and second section, and the first section and fixed section, quickly to reestablish the integrity of the vacuum chamber. Both larger diameter sections may be power operated to move concurrently or independently.

30 In order to achieve quick access and to open and lock the vacuum chamber, there is provided a simplified quick acting preferred lock system between the fixed and a moving section of the vacuum chamber. The lock system utilizes pneumatic piston-cylinder assemblies driving lock blocks behind fixed stop blocks, forcing the sections

together in a direction opposite the forces generated by the fluid seals. The preferred lock system may be utilized whether the fixed and moving sections are substantially the same size or substantially different in size.

To the accomplishment of the foregoing and related ends, the invention then
5 comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

10

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a somewhat schematic side elevation of a vacuum chamber section of a foam extrusion line in accordance with the invention with the chamber fully closed;

Figure 2 is a similar schematic showing one enlarged section opened and telescoped to expose some of the take-off equipment;

15

Figure 3 is a similar schematic showing a second enlarged section open and shifted with the one to expose some of the take-off, shaping or calibrating equipment and the die;

Figure 4 is a section taken substantially on the line 4-4 of Figure 1 showing the eccentric fixed and the larger telescoping first section;

20

Figure 5 is an enlarged fragmentary axial elevation of one form of lock;

Figure 6 is a fragmentary view of the lock of Figure 5 actuator;

Figure 7 is a fragmentary axial section from the fixed section to the fixed bulkhead showing the lock of Figure 5 and the fluid actuated seals;

Figure 8 is a view like Figure 4 but illustrating the preferred lock system; and

25

Figure 9 is a fragmentary broken section of the lock system of Figure 8 taken substantially on the line 9-9 of Figure 8.

DETAILED DESCRIPTION OF THE ILLUSTRATED PREFERRED EMBODIMENTS

Referring now to the drawings and more particularly to Figures 1 through 3 the
30 vacuum chamber section of a foam extrusion line is shown generally at 10. At the right hand or upstream end of the line there is provided one or more extruders shown generally at 11. The extruders are mounted on a stand 12 and include one or more hoppers 13 by which the raw materials are fed to the extruder barrel 15 to be formed under heat and

pressure into a foamable plastic melt. An extension of the extruder barrel may project through a large diameter fixed bulkhead plate indicated at 16 with the die 18 being mounted on the end of such extension within the vacuum chamber. The extruder barrel may extend through a gland as shown in applicants' co-pending application serial number 5 08/696,718 filed August 14, 1996, and entitled "Vacuum Extrusion Apparatus and Method". The die 18 is thus within the chamber and interior of the bulkhead 16. The bulkhead forms the upstream end of the vacuum chamber 10. The opposite or downstream end is in the form of a water baffle immersion cooler shown generally at 20. The chamber at such water baffle end may include interconnected fixed cylindrical 10 sections 23 and 24 which are mounted on fixed stanchions 25 on the floor 26. A fixed exit bulkhead in the form of a dam is provided at 28 near the joint of the two fixed sections 23 and 24, which forms a pond or reservoir 29, one end of which is in essentially all of the section 23. In the section 24 there may be provided a roller conveyer 30 having rollers 31 providing support beneath the extrudate. As the extrudate passes over the top of 15 the dam 28, guide rollers may be provided both above and below the extrudate as indicated at 33 and 34, respectively. These conveyor rollers cause the extrudate to deflect or dip downwardly through a slight curve after having passed over the dam to enter the pond 29 of water. The level of the pond within the chamber when under vacuum is shown at 36.

20 The extrudate passes into a hood 37 and exits the hood beneath the section of the pond indicated at 40 exposed to atmosphere in open pond containment 41. The extrudate is still guided by the conveyor system indicated at 42 on the top of the extrudate. At this point the extrudate will float upwardly against the conveyor system. The extrudate continues through the pond section 40 and exits to atmosphere for cutting and processing.

25 The details of the water baffle and conveyor system for removing the extrudate from the vacuum chamber to the processing point may be seen in the co-pending application of *Lightle et al.* noted above. Under vacuum, the level of the pond indicated at 36 is somewhat above the level 43 of the pond 29 exposed to atmosphere. The pond is kept from overtopping the dam 28 by circulating the water back to the atmospheric end of the 30 pond. Again this is shown in the prior *Lightle et al.* application.

Positioned upstream of the fixed section 24 of the vacuum chamber is a substantially larger movable section shown generally at 44. A second movable section of the same larger diameter is provided at 46, and it will be noted that the fixed bulkhead 16

at the upper end of the upstream end of the chamber is of comparable diameter. Both movable sections are mounted on rollers indicated at 48, in turn mounted on tracks 49 which run parallel to the extrusion line. At least one of the tracks and mating rollers may be a guide system to maintain alignment when the sections 44 or 46 are moved. The 5 rollers and rails are seen more clearly in Figure 4.

Both large diameter movable sections 44 and 46 are provided with drive motors seen at 51 and 52 which may engage chains mounted on the floor indicated at 53. The drives 51 and 52 may be energized much as a garage door opener to move the large diameter sections 44 and 46 either concurrently or individually.

10 Extending from the dam 28 to the large diameter bulkhead 16 is a truss or beam 60. The truss may include rails serving as supports for the relatively complex equipment which is positioned downstream of the die 18 for calibration and sizing purposes. For example, the extrudate after leaving the die 18 may pass through a calibration unit 62 and a sizing or roller take-off 63, and finally a roller take-off 64. Such units are fairly 15 complex and require, particularly at start up, adjustment and fine tuning. With the present invention access to the die, any shaping mechanism downstream of the die, and the complex calibrating and take-off equipment can be had very quickly by movement of one or both of the large diameter movable sections. The large diameter of the movable sections provides the necessary clearance for an operator working in the spatial 20 environment of the downstream equipment or die and also provides a large volume should a foaming extrudate errantly deviate from its intended path.

In comparing Figures 1, 2 and 3 it will be seen that the first movable enlarged section 44 can be opened and closed by telescoping over the fixed section 24. Both 25 sections may be cylindrical and eccentric as seen in Figure 4. When the first section 44 is opened the relative position of the sections as seen in Figure 2 provides a significant gap indicated at 68 between the sections 44 and 46. This exposes the take-off 64 and part of the take-off 63. If access to the take-off 63 or the calibrating equipment 62 or die 18 is required, the enlarged section 46 is simply moved into the gap 68 to achieve the position seen in Figure 3. With the motors 51 and 52 the two enlarged sections may be moved 30 concurrently to the position seen in Figure 3 exposing the die and equipment at the upstream end of the vacuum chamber as indicated by the gap 69.

Referring now to Figures 4 through 7 it will be seen that the first section 44 has an end plate 72 forming an annular interior opening 73 through which the flanged ring 74 of

the fixed section 24 extends. The plate in one form may be provided with an annular shoulder 75 supporting track ring 76 for roller chain 77 supporting locking plates 78. The roller chain may be moved around the track by a piston-cylinder actuator 79. The blind end of the cylinder is pivoted at 80 to the plate 72 while the rod end is pivoted at 82 to bracket 83 secured to the roller chain as seen in Figure 6. As seen in comparing the right and left hand sides of Figure 5, the reciprocation of the actuator will cause the locking plates to move from a clear position shown between a series of spaced projections 84 and 85 to a locking position behind such projections, and vice versa. The relative position of the locking plates and projections is seen in Figures 5 and 7. The projections are on the end of the fixed section. The locking plates are mounted on the roller chain on the end of the movable section. When the piston-cylinder assembly is actuated to obtain the clearance position, one or both of the large diameter movable sections may be moved selectively as shown in Figures 2 and 3.

The diameter of the bulkhead and movable sections may be substantial being on the order of fourteen feet (4.62 meters) or more, while the fixed section may be on the order of ten feet (3.05 meters). The enlargement ratio is thus on the order of about ten to about fourteen or more.

As seen in Figure 7, in order to seal the larger diameter sections, an annular fluid expandible seal is provided at 88 between the fixed section 24 and the movable section 44. A similar annular fluid seal 89 is provided between the two large movable sections 44 and 46, while an annular fluid seal 90 is provided between the section 46 and the fixed bulkhead 16. With the locking plate 78 in the locking position behind the projections 84 and 85, the expansion of the seals 88, 89 and 90 will take up any clearance indicated at 92 seen in Figure 7 providing a fixed abutment between the movable section and the fixed section 24. The expansion of the seals will then provide a sealed vacuum chamber. It is noted that when the vacuum chamber is open, the pond level 36 within the chamber is at the same level as the level 43 outside the chamber. With the chamber closed, the vacuum can quickly be restored.

Referring now to Figures 8 and 9, there is illustrated a preferred locking system for the present invention whether the fixed and telescoping sections are of substantially different or similar sizes. The locking system utilizes pneumatic piston-cylinder assembly actuators shown at 92, 93, 94, 95, 96 and 97 in Figure 8. The actuators are spaced equally 60° apart around the center of the fixed section symmetrically on each side of a vertical

plane through the center.

The blind end of each actuator is pivoted between parallel plate brackets 99 at 100. The brackets extend from the plate 72. Each actuator rod has fixed thereto a lock block 102 which as a transverse follower rod 103, the projecting ends of which ride in cam slots 105 in each bracket plate. The slots are inclined with respect to the axes of the sections and move the lock blocks radially inwardly as the rods of the actuators extend and radially outwardly as the actuators retract. When retracted in the full line position shown, the blocks are radially clear of respective stop blocks 107 secured to the exterior of fixed section 24. When extended to the phantom line position 109, the lock blocks engage 10 behind and abut against the stop blocks, preventing the opening or telescoping of the two sections 44 and 24.

The pressure within the cylinders 92 drives the two movable sections to the right as seen in Figure 9, while pressure within the fluid seals 88, 89 and 90 is counteractive. The lock system of Figures 8 and 9 is preferred for its simplicity and short cycle of action.

15 The system can be used whether the telescoping sections are of similar or dissimilar size.

It can now be seen that there is provided a vacuum extrusion system particularly useful for the production of low density foams with the vacuum chamber utilizing a fixed large diameter entrance bulkhead plate with first and second large diameter movable sections. The first section with the larger diameter is movable and seals against a second 20 section, and telescopes over a smaller diameter fixed section which includes a dam forming part of a full immersion water baffle seal permitting the extrudate to exit the chamber. The second section may move within the gap created by movement of the first section and seals against the first section and an entrance bulkhead plate. A truss supporting the complex downstream equipment extends from the dam to the fixed 25 bulkhead through the movable large diameter sections. In this manner all of the downstream equipment may quickly and conveniently be exposed with proper spatial environment for the operator and any errant extrudate. The vacuum chamber can quickly be restored and sealed after any problems are corrected. The volumetric and access capability is important on start up for large through-put extrusions.

30 To the accomplishment of the foregoing and related ends, the invention then comprises the features particularly pointed out in the claims, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

WHAT IS CLAIMED IS:

1. A vacuum extrusion line comprising a vacuum chamber having a die at one end inside the chamber and a water baffle immersion cooler at the other end for extracting the extrudate to atmosphere, and downstream extrudate shaping and sizing equipment all inside the chamber, and means operative to open the chamber fully laterally selectively to expose said die and any of said downstream equipment.
2. A vacuum extrusion line as set forth in claim 1 wherein said last mentioned means comprises at least two movable sections of said chamber surrounding when closed said die and downstream equipment.
3. A vacuum extrusion line as set forth in claim 2 wherein said chamber includes a fixed section, one of said two movable sections telescoping over said fixed section when moved.
4. A vacuum extrusion line as set forth in claim 3 wherein said movable and fixed sections are cylindrical and said movable sections are substantially larger than said fixed section.
5. A vacuum extrusion line as set forth in claim 4 wherein said movable and fixed sections are eccentric.
6. A vacuum extrusion line as set forth in claim 5 including a dam in part forming said water baffle immersion cooler at said other end, a fixed bulkhead at said one end, and a truss extending from said dam to said bulkhead supporting said downstream equipment and extending through said fixed and two movable sections.
7. An extrusion line as set forth in claim 1 including cylinder means to unlock the chamber for such opening.
8. An extrusion line as set forth in claim 7 wherein said cylinder means is spaced equally around the chamber and is mounted on a movable section of the chamber.
9. An extrusion line as set forth in claim 8 including a fixed section of the chamber, respective stop blocks mounted on said fixed section, and lock blocks driven by said cylinder means against said stop blocks.
10. An extrusion line as set forth in claim 9 including cam means operative to guide lock blocks.
11. A vacuum extrusion line comprising a vacuum chamber having a die at one end inside the chamber and a water baffle immersion cooler at the other end for extracting

the extrudate to atmosphere, and downstream extrudate shaping and sizing equipment all inside the chamber, said chamber comprising a fixed section, and at least two movable sections which can be relatively positioned selectively fully to expose any of said die and downstream equipment to permit quick access thereto.

5 12. An extrusion line as set forth in claim 11 including a dam in part forming said water baffle immersion cooler at said other end, a fixed bulkhead at said one end, and a truss extending from said dam to said bulkhead supporting said downstream equipment and extending through said fixed and two movable sections.

10 13. An extrusion line as set forth in claim 12 wherein said movable and fixed sections are cylindrical and said movable sections are substantially larger than said fixed section.

14. An extrusion line as set forth in claim 13 wherein said movable and fixed sections are eccentric.

15 15. An extrusion line as set forth in claim 13 wherein the diameter ratio of the fixed section to the movable sections is on the order of about 10 to about 14, or more.

16. An extrusion line as set forth in claim 15 wherein said fixed bulkhead has a diameter comparable to the diameter of said movable sections.

20 17. A vacuum extrusion line comprising a vacuum chamber having a die at one end inside the chamber and a water baffle immersion cooler at the other end for extracting the extrudate to atmosphere, and downstream equipment for extrudate shaping and sizing all inside the chamber, said chamber comprising a fixed section and at least two movable sections, one of which telescopes over said fixed section to form a gap, with the other then being movable within the limits of the gap selectively fully to expose the die and downstream equipment.

25 18. An extrusion line as set forth in claim 17 including means to move said two movable sections concurrently or independently.

19. An extrusion line as set forth in claim 17 including a dam in part forming said water baffle immersion cooler at said other end, a fixed bulkhead at said one end, and a truss extending from said dam to said bulkhead supporting said downstream equipment and extending through said fixed and two movable sections.

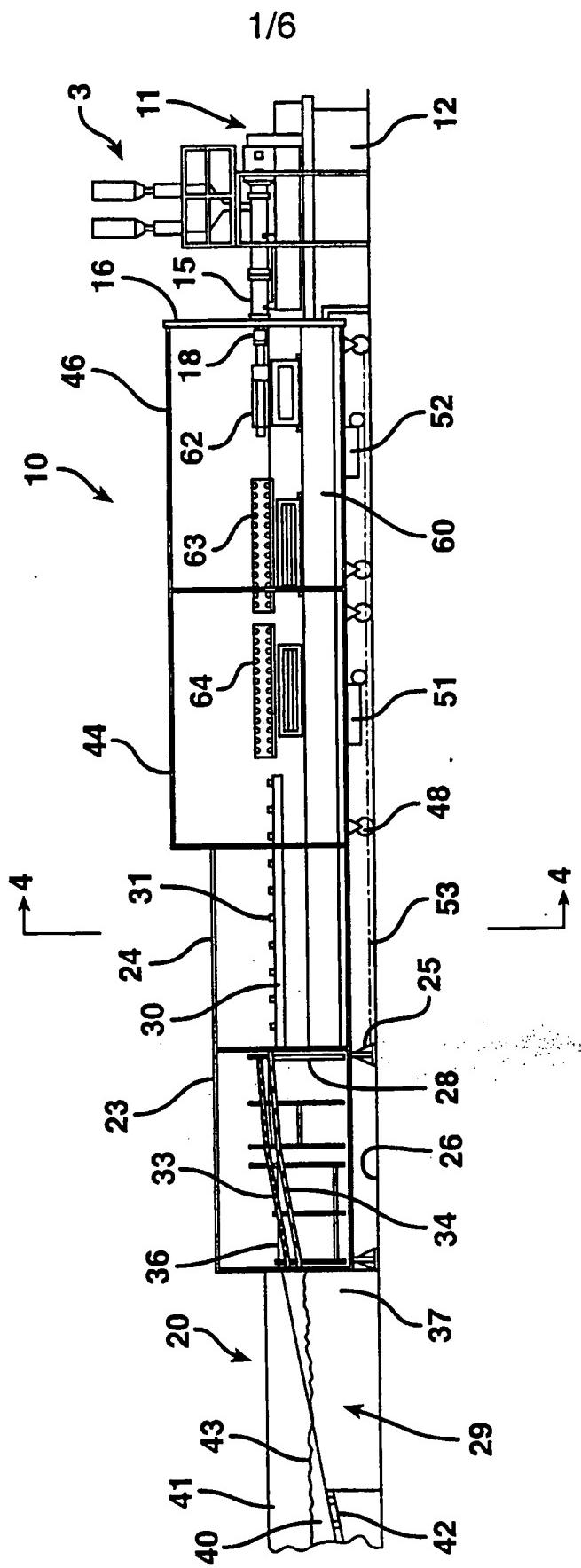
30 20. An extrusion line as set forth in claim 17 wherein said movable and fixed sections are cylindrical and said movable sections are substantially larger than said fixed section.

21. An extrusion line as set forth in claim 20 wherein the diameter ratio of the fixed section to the movable sections is on the order of about 10 to about 14, or more.
22. An extrusion line as set forth in claim 21 wherein said fixed bulkhead has a diameter comparable to the diameter of said movable sections.
- 5 23. A vacuum extrusion system including a vacuum chamber having a fixed and movable section, the movable section being mounted for telescoping movement over said fixed section, stop blocks on said fixed section, and respective lock blocks on said movable section operative to be driven against said stop blocks by respective cylinder actuators to lock said sections closed.
- 10 24. An extrusion line as set forth in claim 23 including cam means to guide said lock blocks into engagement with said stop blocks, when locking the chamber, and clear of said stop blocks when opening the chamber.
25. An extrusion line as set forth in claim 24 wherein each lock block is mounted on the rod of a respective piston-cylinder assembly.
- 15 26. An extrusion line as set forth in claim 25 wherein each lock block includes a transverse follower, and a cam engaging said follower to move the lock block to and from the clear and engagement positions.
27. An extrusion line as set forth in claim 23 including fluid seals for said chamber, said actuators counteracting forces generated by said fluid seals.
- 20 28. An extrusion method comprising the steps of forming an extrudate through a die in one end of a vacuum chamber, passing the extrudate through sizing and shaping equipment downstream of the die, and passing the extrudate through a water baffle immersion cooler at the opposite end of the chamber to enable the chamber to be maintained under vacuum as the extrudate continually exits to atmosphere, and providing the chamber with movable and sealable sections surrounding the die, sizing, and shaping equipment, and selectively moving said sections fully laterally to expose any of the die, sizing, and shaping equipment.
- 25 29. A method as set forth in claim 28 including the step of providing at least two movable sections, and a fixed section, at least one of said movable sections telescoping over said fixed section.
30. A method as set forth in claim 29 including the step of moving said movable sections concurrently or independently.
31. A method as set forth in claim 30 including the step of forming the moving

and fixed sections as cylindrical sections with the movable sections being substantially larger than the fixed section.

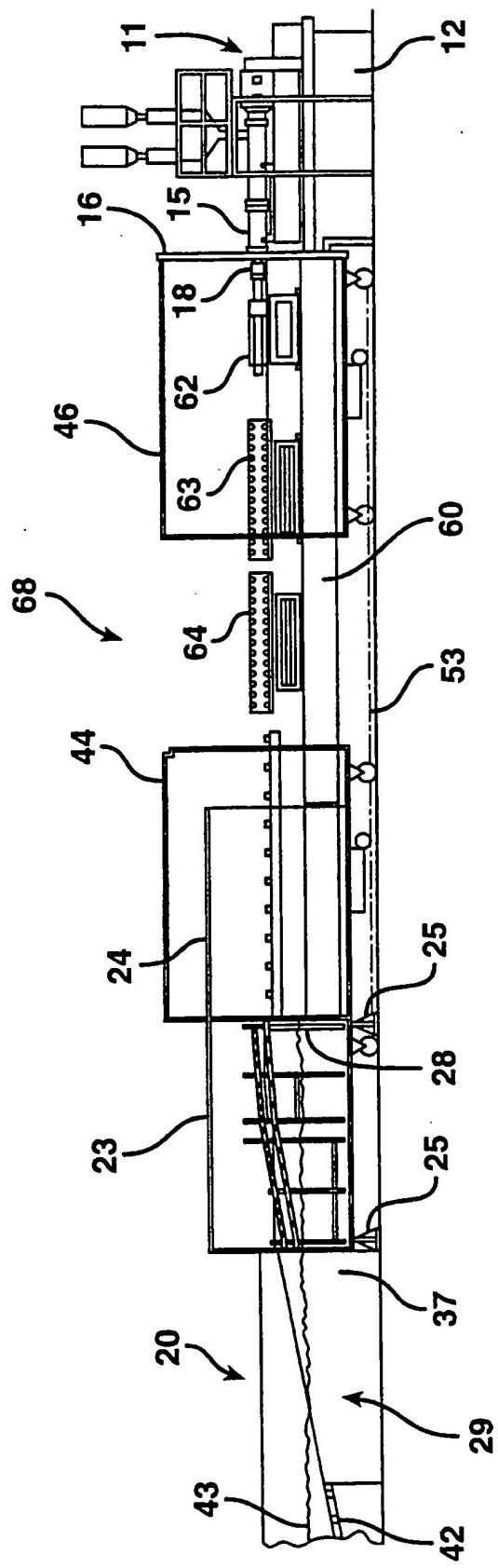
32. A method as set forth in claim 31 forming the sections so that diameter ratio of the fixed section and movable sections is on the order of about 10 to about 14.

FIG.



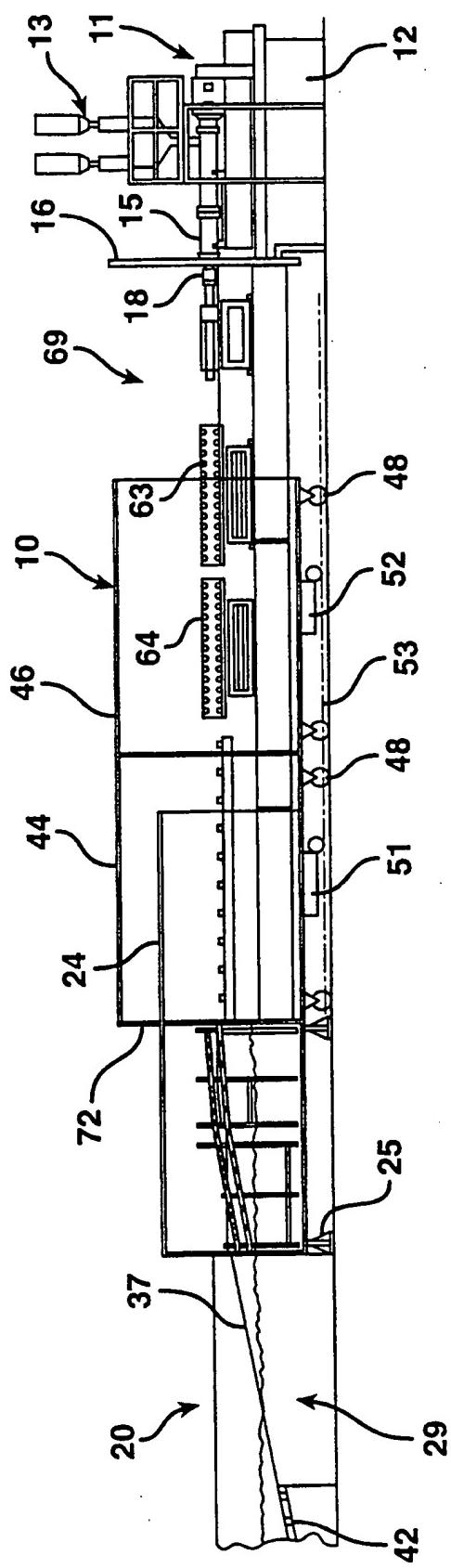
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FIG. 2



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FIG. 3



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FIG. 4

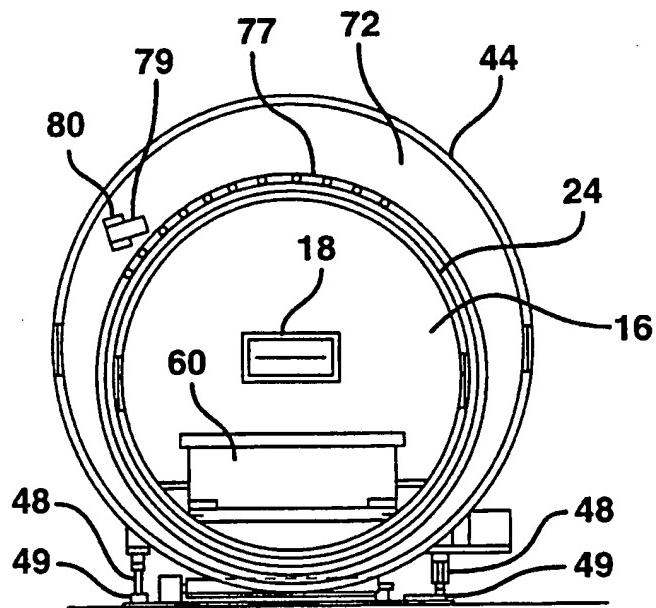
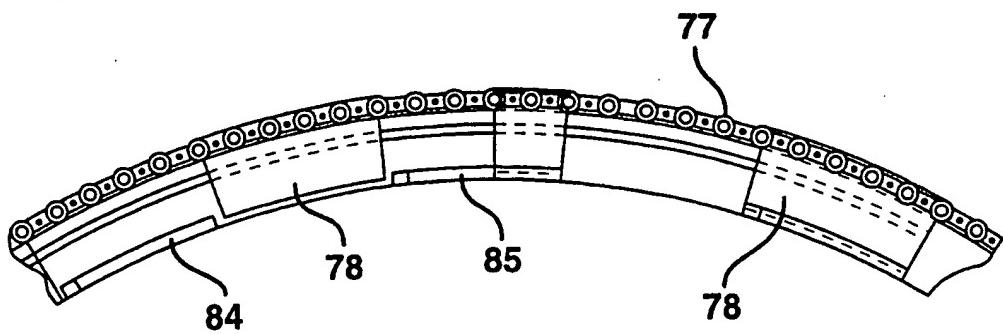


FIG. 5



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FIG. 6

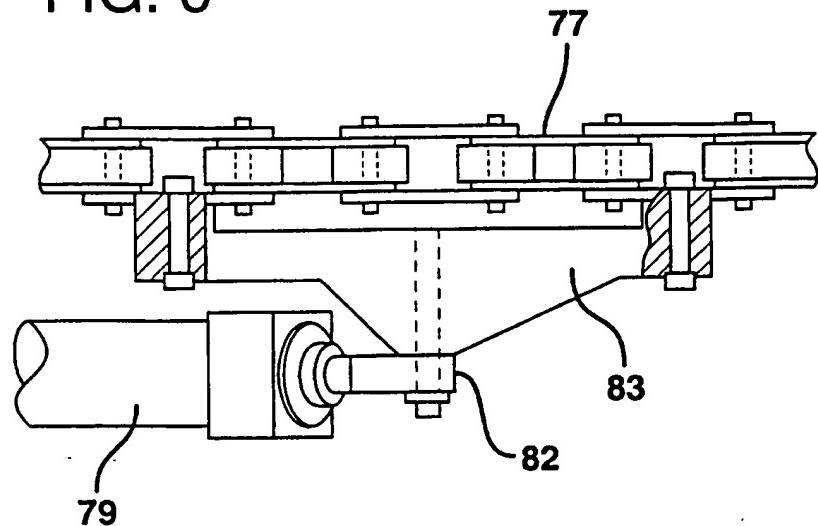
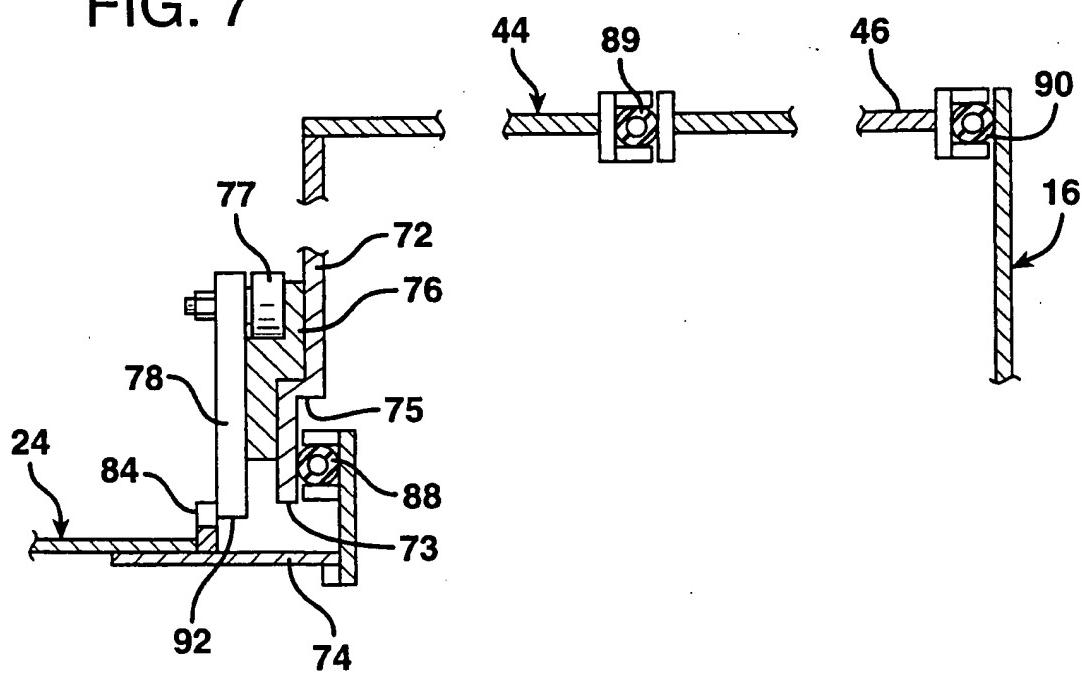


FIG. 7



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FIG. 8

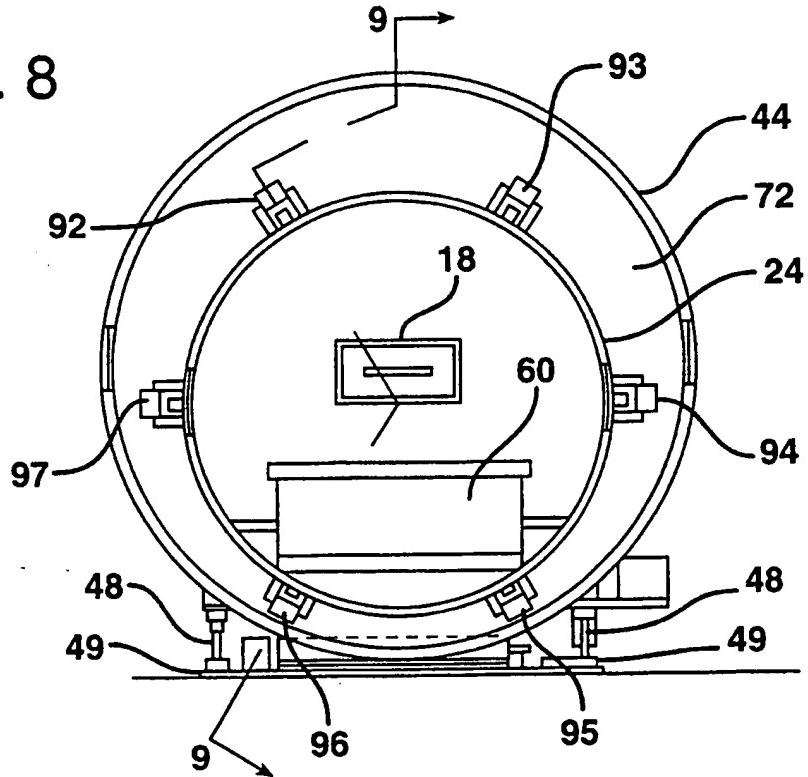
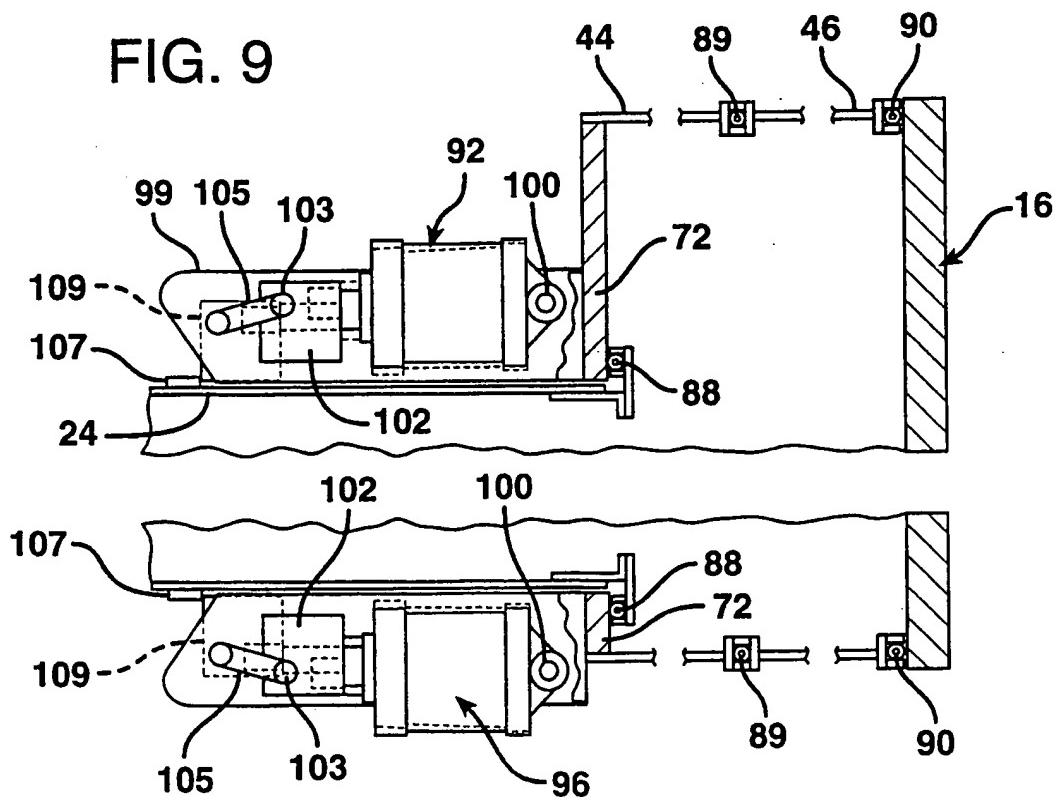


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/16400

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B29C 44/50, 44/56, 44/90

US CL :Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 264/51, 101, 178R, 560, 562; 425/4C, 71, 73, 186, 192R, 325, 326.1, 388, 817C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,783,291 A (PAGAN) 08 November 1988, see figure 1 and col. 2, line 68, to col. 3, line 3.	1, 28 -----
---		2, 11
Y		
X, P	US 5,753,161 A (LIGHTLE et al.) 19 May 1998, see entire document.	1, 7, 8, 28 -----

Y, P		2-6, 11-22, 29-32
Y	US 4,486,369 A (SCHAFLER et al.) 04 December 1984, see fig. 8 and col. 15, lines 4-18.	2-6, 11-22, 29-32
Y	US 4,487,731 A (KOBAYASHI) 11 December 1984, col. 7, lines 12-18.	2-6, 11-22, 29-32
A	US 4,271,107 A (PHIPPS) 02 June 1981, see figure 1.	1

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER:
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264/51, 101, 178R, 560, 562; 425/4C, 71, 73, 186, 192R, 326.1, 388, 817C